



Determination of nutritional potential of five important wild edible fruits traditionally used in Western Himalaya

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ABSTRACT

Wild edible fruiting plants sustain numerous organic phytochemicals and significantly contribute to the nutritional security of mankind that have been linked to the promotion of good health. However, the detailed analysis of health promoting organic compounds and nutritive minerals present in these fruits were explored very little in the Himalayan region. In the present investigation, nutritional potential of five wild edible fruits of the plant species like *Rubus ellipticus* Smith, *Rubus paniculatus* Smith, *Benthamidia capitata* Wllichex. Roxb, *Coriaria nepalensis* Wllich and *Pyracantha crenulata* D.don. were evaluated by determining proximate nutrient and mineral analysis. This study indicated that highest carbohydrates (80.71g/100g) and protein (10.49g/100g) was recorded in *P. crenulata* and *C. nepalensis* respectively, however, fat (4.56g/100g), sugar (27.95g/100g) and energy value (373.28 Cal/100g) were recorded maximum in *R. paniculatus*. Contrary to this the mineral composition in all fruits varied greatly and maximum nitrogen value (1.67%) was found in *C. nepalensis*, whereas minimum (1.35%) in *P. crenulata*. The Phosphorous was recorded highest (56.83%) in *R. ellipticus* and lowest (30.55%) in *C. nepalensis*. However, the Calcium was found greater (63.76 mg/100g) in *R. paniculatus* while lower (53.06mg/100g) in *R. ellipticus* fruit. The study revealed that these wild fruits exhibited high nutritional composition therefore, could be used as supplementary diet in mountain region and should be promoted to conserved and enhance their genetic diversity.

Key words: Organic phytochemical; nutritional potential; Energy value; Supplementary diet

INTRODUCTION

Garhwal Himalaya is characterized by a rich heritage of wild edible plants and is the precious gift from nature to the ethnic communities. It is better income source to the tribal people, as they collect wild edible fruits for selling as well as for their own use. Carbohydrate, fats and proteins consti-

tuted the major portion of the diet. However, mineral and vitamins form comparatively smaller part. Moreover, plant material form a major portion of the diet, hence it is important to know the nutritive value of the plants. Millions of people in many developing countries do not have enough food to meet their daily requirements and are deficient in one or more nutrients (FAO, 2004). In developing countries, wild plants are exploited as sources of food and other life supporting commodities and thus provide an adequate level of nutrition to the human beings (Aberoumand and Deokule, 2010). These plants serve as an indispensable constituent of human diet supplying the body with minerals, vitamins and certain hormone precursors, in addition to protein and energy (Akubugwo et al., 2007). From far ancient time, plants have been used as a source of food, shelter, clothing, medicine, fiber, gum, resin and oil etc. Several wild plants are used as food by tribal communities and other local inhabitants residing around the forest areas.

The wild edible fruits are one of the important groups of non-timber forest products (NTFPs) that played a significant role in uplifting the socio-economy of tribal and rural communities (Maikhuri and Ramakrishnan, 1992; Maikhuri et al., 2004; Dhyani et al., 2007). Fruiting plants are not only supplement food quantity but also an important option during starvation for survival and thus make significant contribution to the human nutrition. The wild edible plants diversity are widely distributed in mountain forest and are valuable source of food and medicines for domestic and commercial purposes. Additionally, these plants also provides some useful products like fiber, fodder, tannin, resin and dyes etc. (Kayang, 2007). However, some wild fruits have been identified to have better nutritional value than cultivated fruits (Eromosele et al., 1991; Maikhuri et al., 1994). Wild fruits provide nutrition for forest dwellers and many of the marginalized rural communities since the common cultivated fruits are less familiar and not reachable for them. Contrary to this, the wild fruits used by tribal are not much familiar to the urban communities. The rich ethnic communities of Garhwal Himalaya have immense traditional knowledge on the utilization of forest and plant parts especially as fruit in multi varied ways of application (Sundriyal et al., 1998). The Himalaya, one amongst the biodiversity rich area, supports over 675 species of wild edible plants for their seeds, fruits, seed oil, vegetable, tuber, rhizome and roots (Samant and Dhar, 1997). The extreme diversity of wild edible fruits plants in the Indian Himalayan Region

(IHR) has traditionally been known to play crucial role in meeting nutritional, minerals and antioxidant requirement of indigenous communities (Maikhuri et al., 2004; Andola et al., 2008; Rawat et al., 2011). However, the systemic investigation on nutritional and antioxidant potential of the wild edibles in the region are meagre (Sundriyal and Sundriyal, 2001; Badhani et al., 2015; Belwal et al., 2016). These wild fruiting trees/shrubs grow abundantly across an altitudinal gradient of the Himalaya and majority of these bear fruit during summer. These plants are precious individually and their genetic diversity should be conserved and enhanced. In addition, many of these used locally, but are not yet popular. There are number of wild edible fruiting plants species in Garhwal Himalaya but in spite of this, these plants have not been well explored so far for their nutritive values. This study explores the nutritional status of five wild edible fruits of Garhwal Himalaya by profiling their biochemical attributes i.e., moisture, fat, protein, carbohydrate, sugars and micronutrient.

MATERIALS AND METHODS

Plant Material

A reconnaissance survey of nearby forests in Bhagirathi Catchment area of Tehri district of Uttarakhand was done and five nutrient rich wild edible fruits viz., *Rubus ellipticus* Smith. (Rosaceae), *Rubus paniculatus* Smith. (Rosaceae), *Benthamidia capitata* Wallich ex Roxb. (Cornaceae), *Coriaria nepalensis* Wallich. (Coriariaceae), *Pyracantha crenulata* D. Don. (Rosaceae) were selected from different localities for their biochemical analysis. Every effort was made to collect these plants in both flowering and fruiting conditions for the correct scientific identification. Moreover, each plant voucher was brought to laboratory and identified with the help of available flora of the district Garhwal North West Himalaya (Gaur, 1999), existing taxonomic literature and Herbarium of HNB Garhwal University Srinagar (GUH). Fresh, healthy and disease free ripened fruits (approximate 500 g) from four to five plants of each species were collected in polythene/sample bag. All samples were washed thoroughly to remove any attached soil and other impurities and external moisture wiped out with a smooth dry cloth. Further, the sampled fruits were dried under shade conditions so decomposition of available content/minerals could be prevented. The fully dried fruit sample/material of each species were then powdered in blender and used for

further biochemical nutritional and mineral analysis. The blender was washed thoroughly before using for next fruit to avoid mixing of samples/powdered.

Proximate nutrient and mineral biochemical Analysis

Moisture content

The moisture content for fruit samples of each species was estimated as per AOAC (2000). Ten gram of sample was taken in a flat-bottom dish and kept overnight in an air oven and dried at 100–105°C. The initial weight (saturated weight) and dried weight were noted and calculated as:

$$\text{Moisture contents (\%)} = \frac{\text{Fresh weight} - \text{dry weight}}{\text{Fresh weight}} \times 100$$

Acidity

The acidity of fruit was determined by titration of a known weight of sample with NaOH using Phenolphthalein indicator. The value was calculated with reference to percent tartaric acid (Rangana, 1979).

Estimation of total carbohydrate, Protein and Fat

For the quantitative analysis of Carbohydrate, the sample extract was prepared by hydrolyzing the test sample in 2.5N HCl for three hours in boiling water bath, followed by neutralizing it with sodium carbonate. It was then centrifuged and the supernatant was collected for analysis. The analysis was carried out using method proposed by Hedge and Hofreiter (1962). The protein was estimated by the folin-ciocalteu reagent method following by Lowry *et al.* (1951). The fat was extracted from 1 gm aliquots by heating in alcoholic HCl, followed by the addition of 95% ethanol. The sample was allowed for cooling, further, ether and sodium sulphate was added and the sample was shaken properly. After a while, petroleum ether was added and sample was shaken again. The acidic ethanol layer was re-extracted twice more with a mixture of petroleum ether. The combined, recovered supernatants were allowed to evaporate in a ventilated area and any trace of moisture was eliminated by drying in a forced air oven (100 °C, 1.5 h) prior to gravimetric determination as per modified AOAC method 14.019 (Conway and Adams, 1975).

Total sugar (TS) and Reducing Sugar (RS)

The total sugar was estimated using anthrone's reagent (Rangana, 1979). 1 ml of alcoholic extract was taken in a test tube and chilled. After few minutes 4 ml of anthrone's reagent was carefully run down the walls of the test tube. The test tubes were thereafter immersed

in ice water. The tubes were brought to ambient temperature and boiled in water bath for 10 minute. After proper cooling, the absorbance was measured on spectrophotometer wavelength at 625nm. The reducing sugar was estimated using Dinitrosalicylic acid (DNS) reagent (Miller, 1972). 3 ml of DNS reagent was added to 3 ml of sample in a lightly capped test tube. The mixture was heated at 90°C for 5-15 minutes to attain a red brown color. Then 1 ml of Rochelle's salt solution was added to stabilize the colour. After cooling to room temperature in cold water bath, absorbance was recorded at 575 nm.

Total Energy/Nutritive value

The nutritive value was calculated as: Nutritive value = 4 × Percentage of protein + 9 × Percentage of fat + 4 × Percentage of carbohydrate following Indrayan *et al.* (2005) and Nwabueze (2006).

Nitrogen, Phosphorus and Calcium

The Nitrogen percentage was estimated by using Micro-Kjeldahl digestion and distillation technique. The sample was digested by boiling with concentrated Sulfuric acid in the presence of catalyst Copper Sulfate. The digestion converts all the nitrogen to ammonia, and trapped as ammonium sulfate. On completion of the digestion stage is generally recognized by the formation of the clear solution. The ammonia was released by the addition of excess sodium hydroxide and was removed by steam distillation. Further, it was collected in boric acid and titrated with standard hydrochloric acid using methylene blue as an indicator. Available phosphorus content was estimated colorimetrically by treating the digested sample with ammonium molybdate and freshly prepared ascorbic acid. Spectrophotometer apparatus was used to measure the absorbance at 880 nm. Calcium in fruit samples were determined by EDTA (the disodium salt of ethylene-diamine-tetra-acetic acid) titration method (Allen, 1989; Anderson and Ingram, 1993; Rangana, 1979).

Statistical Analysis

A two tailed Pearson correlation was conducted between various nutritional constituents of selected wild fruits using SPSS.

RESULTS AND DISCUSSION

All recorded species were extensively distributed from lower dry tropical to middle moist temperate forests of Garhwal Himalaya and generally grow in the association

of Oaks (*Quercus* spp.). Somewhere, they were noticed in association with *Pinus roxburghii* forests. The fruits are considered to be the richest source of carbohydrates, either monosaccharide or polysaccharides such as cellulose and starch (Demir and Ozcan, 2001; Ozcan and Haciseferogullari, 2007). The ethno medicinal importance of studied wild fruits is given in Table 1. In this study the edible part of fresh plant material of species such as *Rubus ellipticus* Smith (Rosaceae), *Rubus paniculatus* Smith (Rosaceae), *Benthamidia capitata* Wallich ex Roxb. (Cornaceae), *Coriaria nepalensis* Wallich. (Coriariaceae) and *Pyracantha crenulata* D. Don. (Rosaceae) contained relatively high moisture content compared to other nutritive values like protein, fat, and carbohydrate (Figure 1 and Table 2). The available mineral like calcium, phosphorus and nitrogen were found varied in concentration (Table 3).

The percent values of moisture content in all fruits were oscillated between 70.33% (*Benthamidea capitata*) and

84.0% (*Rubus paniculatus*). The fruits of other species have comparatively lower moisture values. The recorded moisture percent values were found similar to the values (55.11 to 87.41%) reported by Mahapatra *et al.* (2012). The greater moisture in these fruit samples may be due to growing in moist habitat along a riverine system of Garhwal Himalaya. The acidity percent existed highest (1.87%) in *Coriaria nepalensis*, whereas lowest (1.47%) in *Rubus ellipticus*. The detailed values of acidity and moisture content are presented in Figure 1. The illustrated photo graphs of all species as identified are given in figure 2. The *Coriaria nepalensis* have comparatively higher protein content value (10.49g/100g) with moderate (77.30g/100g) carbohydrates. However, *Pyracantha crenulata* accounted lower (8.47g/100g) protein with high (80.71g/100g) total carbohydrates. The carbohydrate in *Pyracantha crenulata* was found similar to the values for fruits like *Mangifera sylvatica* Rox. (80.81%) and *Terminellia chebulla* Retz. (80.61%) from Himalayan region (Sundriyal and Sundriyal, 2001), while higher than the range (7.20 to 22.30%) reported

Table 1: Medicinal uses of selected wild edible fruits

SN	Species	VN	Family	Medicinal uses	Reference
1.	<i>Rubus ellipticus</i>	Hissar/Hinsar	Rosaceae	Whole plant used to cure dihorrea, root paste applied on skin disease and used in Stomach-ache	Kapakoti et al. (2014) Bisht et al. (2013), Gaur and Jyotsna (2011)
2.	<i>R. Paniculatus</i>	Kala hinsar	Rosaceae	Fruit Syrup used for cold and cough	Chakraborty et al. (2017)
3.	<i>Benthamidia capitata</i>	Bhamora	Cornaceae	Provide strength	Phondani (2011)
4.	<i>Coriaria nepalensis</i>	Rikhola	Coriariaceae	For emetic, bark paste applied in burns and scalds	Gaur (1999), Kunwar et al. (2010)
5.	<i>Pyracantha crenulata</i>	Ghingaroo	Rosaceae	Powdered of dried fruit used with yoghurt to cure bloody dysentery, leaf paste applied on burns	Arora and Pandey (1996), Bisht et al. (2013) Uniyal and Shiva (2005)

Table 2: Important nutritional content in some wild edible fruits

Species	<i>R. ellipticus</i>	<i>R. paniculatus</i>	<i>C. nepalensis</i>	<i>B. capitata</i>	<i>P. crenulata</i>
Total Fat (g/100g)	2.86	4.56	1.37	0.71	0.54
Protein (g/100g)	8.83	8.77	10.49	8.51	8.47
Total Carbohydrate (g/100g)	77.77	74.29	77.3	78.51	80.71
Sugar (g/100g)	24.4	27.95	21.13	23.49	7.16
Reducing sugar (g/100g)	4.14	4.56	3.91	3.68	2.29
Energy value Cal/100g	372.14	373.28	363.49	354.47	361.58

Table 3: Mineral content values of some important wild edible fruits

Species	N %	P %	Ca (mg/100g)
<i>Rubus ellipticus</i>	1.40	56.83	53.06
<i>Rubus paniculatus</i>	1.39	44.44	63.76
<i>Coriaria nepalensis</i>	1.67	30.55	53.87
<i>Benthamidia capitata</i>	1.36	49.41	59.00
<i>Pyracantha crenulata</i>	1.35	45.26	54.50

Table 4: Two tailed Pearson correlation among various nutritive constituents of different wild edible fruits

Constituents	M	A	F	Pr	C	S	RS	EV	N	P	Ca
Moister (M)	1										
Acidity (A)	-.493	1									
Fat (F)	.847	-.311	1								
Protein (Pr)	-.307	.354	-.047	1							
Carbohydrates (C)	-.581	-.152	-.882*	-.233	1						
Sugar (S)	.903*	-.337	.982**	-.222	-.824	1					
Reducing Sugar (RS)	.326	.100	.777	.275	-.908*	.683	1				
Energy Value (EV)	.831	-.636	.885*	.061	-.634	.842	.556	1			
Nitrogen (N)	-.337	.377	-.080	.999**	-.210	-.254	.254	.025	1		
Phosphorous (P)	.208	-.618	.181	-.798	.144	.274	.037	.181	-.807	1	
Calcium (Ca)	.513	.385	.554	-.344	-.668	.636	.446	.140	-.350	.019	1

*. Correlation is significant at the 0.05 level (2-tailed).

** . Correlation is significant at the 0.01 level (2-tailed).

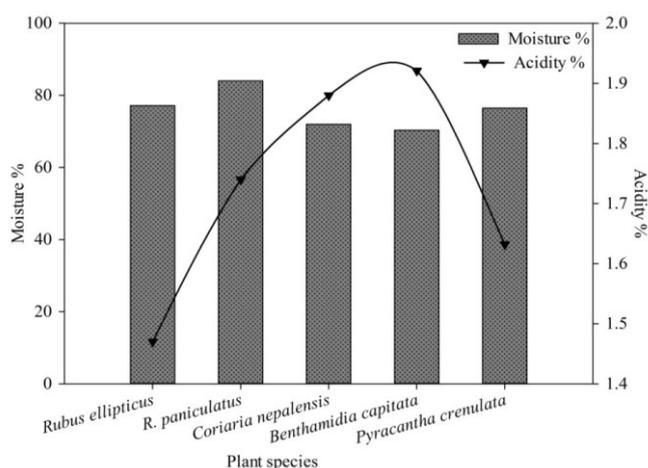


Fig. 1. Moisture and Acidity percent in different wild edible fruits.

by Gopalan *et al.* (2004) for some commercially cultivated fruits, (3.1 to 19.01%) from deciduous forest by Maha-patra *et al.* (2012) and 4.37±0.52% (*Rubus ellipticus*) by Ahmad *et al.* (2005). The protein content in *Rubus spp.* ranged between 8.77 g/100g and 8.83g/100g. Our values are higher than the value (3.68±0.04%) reported by Saklani *et al.* (2012) and existed in the range 1.25 to 10.32g/100g reported by Sundriyal and Sundriyal (2001) for 19 wild edibles fruits from Indian Himalayan region. Carbohydrates are the important component of storage and structural material in the plants and animals. They existed in the form of sugar and polysaccharides. Consequently, due to rich quantity of proteins and carbohydrates, the edible fruits selected in this study may be recommended as supplementary food material for future generation in many ways. The total fat content was varied from 0.54g/100g (*Pyracantha crenulata*) to 4.54g/100g (*Rubus paniculatus*). The recorded fat content values

were lower than previously reported range (0.10 to 64.80%) by Gopalan *et al.* (2004) for many commercial fruits, 0.05 to 30.50% by Sundriyal and Sundriyal (2001) for fruits collected from Himalayan region and 2.6 to 4.0% by Andola *et al.* (2011) for *Berberis* species of Western Himalaya.

In this study, the total sugar content found to be highest (27.95g/100g) in *Rubus paniculatus*, followed by *Rubus ellipticus* (24.40g/100g) and *Benthamidia capitata* (23.49g/100g). However, *Pyracantha crenulata* contain lowest sugar content (7.16g/100g) (Table 2). The higher sugar content in fruits of *Rubus* species i.e., *Rubus ellipticus* and *Rubus paniculatus* likely due to lower acidity. The *Pyracantha crenulata* may be recommended as supplementary food material for the diabetic patients due to adequate protein and carbohydrates and lower sugar content. It could be taken in powder as well as converted into juice form. As shown in Table 2, the gross nutritive value was highest in *Rubus paniculatus* (373.28 Cal/100g), followed by *Rubus ellipticus* (372.14 Cal/100g), whereas *Benthamidia capitata* has least (354.47 Cal/100g) nutritive value.

The mineral composition of five wild fruits plants are given in Table 3. Mineral elements play an important role in regulating many vital physiological processes in the human body such as enzyme regulation, skeletal structure, neuromuscular irritability and clotting of blood (Kalita *et al.*, 2006). Sankran *et al.* (2006) have suggested that human diet should provide a sufficient nutrient for maintenance of growth and proper body functions. Consequently, lack of adequate quantities of mineral in the diet may affect growth and cause irrecoverable deficiency. In this study, the nitrogen

percent was maximum for *Coriaria nepalensis* (1.67%), followed by *Rubus ellipticus* (1.40%), *Rubus paniculatus* (1.39%), *Benthamidia capitata* (1.36%) and *Pyracantha crenulata* (1.38%). Our values were found higher than the values (0.02 to 0.09%) reported by Saha *et al.* (2014) from different places of Arunachal Pradesh. However, they have maintained some higher values for fruits such as *Amanita* spp. (4.22%), *Auricularia auricular-judae* (Bull) J. Schort (2.45%), *Laetiporus sulphureus* (Bull) Murrill (3.36%), *Pleurotus sajor-caju* (Fr.) Singer (3.36%) and *Prasiola-crispa* f. (6.06%). The

Phosphorus percent was oscillated between 30.55% (*Coriaria nepalensis*) and 6.83% (*Rubus ellipticus*). A significant variation was noticed in phosphorus content among all species. Phosphorus regulates various endo-physiological functions including skeletal development, metabolization of mineral, transfer of energy through mitochondrial metabolism, cell signaling and aggregation of blood platelets. Maikhuri (1991) had defined that due presence of phosphorous, normal homeostasis maintained serum concentration between 2.5 to 4.5 mg/dl.

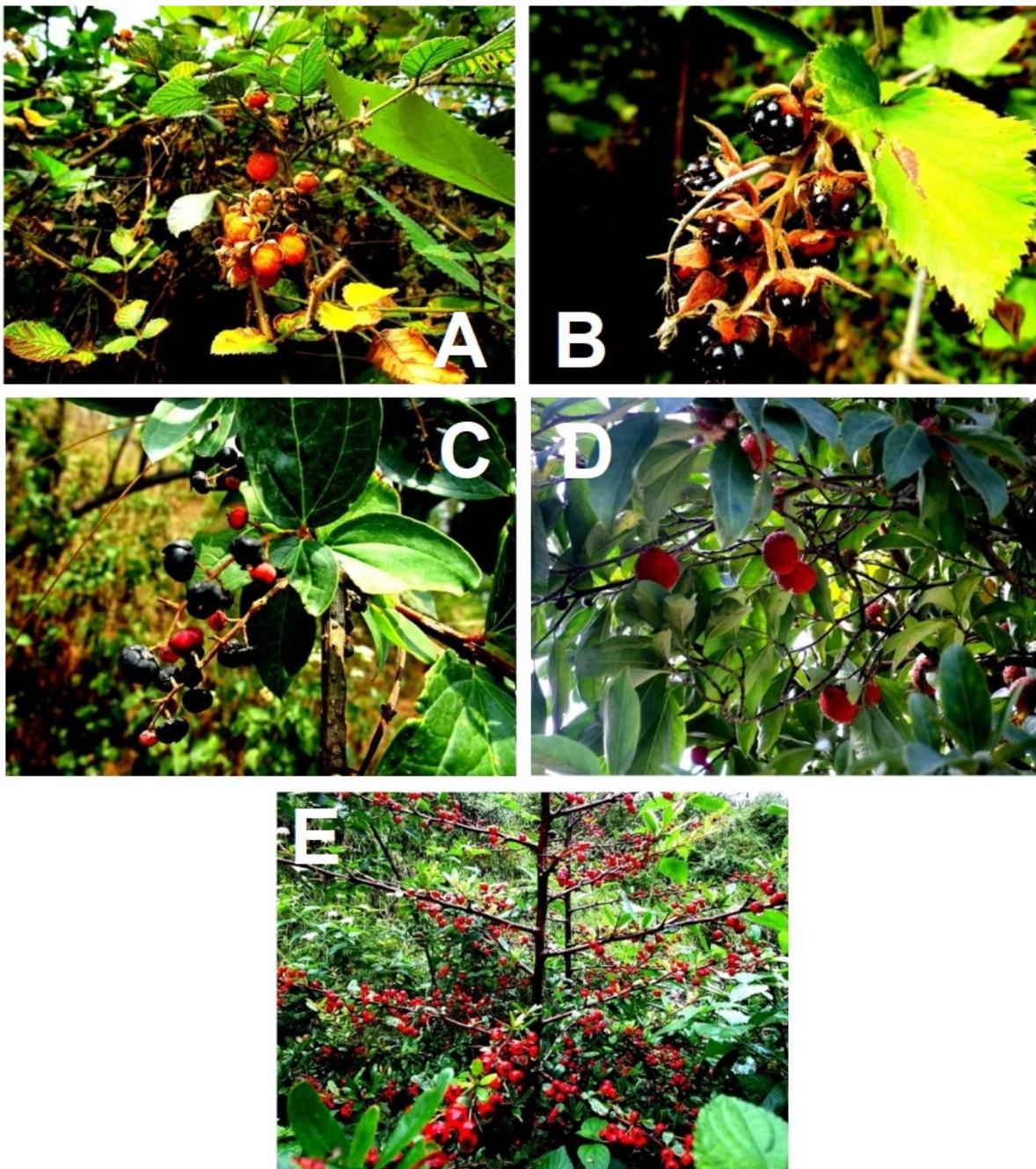


Fig. 2. Photo plats of some studied wild edible fruiting plants (A) *Rubus ellipticus* (B) *Rubus paniculatus* (C) *Coriaria nepalensis* (D) *Benthamidia capitata* (E) *Pyracantha crenulata*

In this study we have recorded high calcium value (63.76 mg/100g) in *Rubus paniculatus*, whereas lower (53.06 mg/100g) in *Rubus ellipticus*. The recorded calcium in selected wild fruits was higher to earlier reported values for some important commercial fruits viz., Apple, Chestnut, Litchi, Mango and Papaya by Gopalan *et al.* (2004). Calcium is an important mineral of human body which constitutes a major proportion of bone, human blood and extracellular fluid. It is necessary for the normal functioning of cardiac muscles, blood coagulation and regulation of cellular permeability. Calcium also plays a crucial role in nerve-impulse transmission and in the mechanism of neuromuscular system.

The Pearson correlation details are presented in Table 4. This study has indicated that the carbohydrates was negatively (-0.882) and significantly correlated with fat. Similarly, reducing sugar was found negatively (-0.908) and significantly correlated with carbohydrates. However, sugar content indicated a positive (0.903) and significant correlation with moisture. Moreover, sugar (0.982) and energy value (0.885) have also shown a positive and significant correlation with total fat.

CONCLUSION

The study showed that wild fruits of Himalayan region are found to be nutritious and available mainly during summer season. The local inhabitants have immense knowledge of wild edible food plants to ensure food security either in dried form or through storage method along with their traditional medicinal utility. *R. ellipticus* and *R. paniculatus* were rich in protein, carbohydrates, fat, sugar, energy value and mineral contents such as nitrogen, phosphorus and calcium. These fruits might be an alternative as they contained high nutritional and mineral to the food industries as new food ingredient for food supplement. Some artificial propagation methods should be adopted to increase the population which ultimately promoted the production of raw material at commercial level. Genetically superior varieties of such species may be evolved through various breeding methods to increase their fruit size.

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Conflict of interest

The authors declares that they have no conflict of interest.

REFERENCES

- Aberoumand A and Deokule SS (2010) Preliminary studies on proximate and mineral composition of marchubeh stem (*Asparagus officinalis*) vegetable consumed in the Behbahan of Iran. *World Appl Sci J*, 9: 127-130.
- Ahmad M, Masood S, Sultana S, Hadda TB, Bader A and Zafar M (2015) Antioxidant and nutraceutical value of wild medicinal Rubus berry. *Pak J Pharm Sci*, 28(1): 241-247.
- Akubugwo IE, Obasi AN and Ginika SC (2007) Nutritional potential of the leaves and seeds of black nightshade-*Solanum nigrum* L. Var virginicum from afikpo-Nigeria. *Pak J Nutr*, 6: 323-326.
- Allen SE (1989) Chemical analysis of ecological materials 2nd ed. Blackwell scientific publications, London.
- Anderson JM and Ingram JSI (1993) Tropical soil biology and fertility: A handbook of methods. 2nd ed. CAB international, Walling Ford, UK.
- Andola HC, Rawal RS and Bhatt ID (2011) Comparative studies on the nutritive and anti-nutritive properties of fruits in selected *Berberis* species of West Himalaya, India. *Food Res Int*, 44: 2352-2356.
- Andola HC, Rawal RS and Bhatt ID (2008) Antioxidant in fruits and roots of *Berberis asiatica* Rox. Ex DC.: A highly valued Himalayan plant. *Natl Acad Sci Lett*, 31: 337-340.
- AOAC (2000) *Association of Official Analytical Chemists*. 16th edn. Washington DC.
- Arora RR and Pandey A (1996) Wild edible plants of India: Conservation and use. New Delhi: Indian Council for Agricultural Research, National Bureau of Plant Genetic Resources.
- Badhani A, Rawat S, Bhatt ID and Rawal RS (2015) Variation in chemical constituents and antioxidant activity in Yellow Himalayan (*Rubus ellipticus* Smith) and hill raspberry (*Rubus niveus* Thunb.). *J Food Biochem*, 39: 667-672.
- Belwal T, Dhyani P, Bhatt ID, Rawal RS and Pandey V (2016) Optimization extraction conditions for improving phenolic content and antioxidant activity in *Berberis asiatica* fruits using response surface methodology (RSM). *Food Chem*, 207: 115-124.
- Bisht VK, Kandari LS, Negi LS, Bhandari AK, Sundriyal RC. (2013) Traditional use of medicinal plants in district Chamoli, Uttarakhand, India. *J Med Plants Res*, 7(15): 918-929.
- Conway ES and Adams M (1975) Determination of fat in body tissues and food mixtures. *J Assoc Off Anal Chem*, 58: 23-32.
- Demir F and Ozcan F (2001) Chemical and technological properties of rose (*Rosa canina* L.) fruits grown wild in Turkey. *J Food Eng*, 47(4): 333-336.
- Dhyani D, Maikhuri RK, Rao KS, Kumar L, Purohit VK, Sundriyal M and Sexena KG (2007) Basic nutritional attributes of *Hippophae salicifolia* (Seabuckthorn) populations from Uttarakhand Himalaya, India. *Curr Sci*, 92(8): 1148-1152.

- Eromosele IC, Eromosele CO and Kuzhkzha DM (1991) Evaluation of mineral elements and ascorbic acid contents in fruits of some wild plants. *Plant Food Hum Nutr.*, 41: 151-154.
- Food and Agricultural Organization of the United Nations (FAO) (2004) The state of food insecurity in the world. Monitoring the progress towards the world food summit 2nd millennium development goals. Annual Report Rome.
- Gaur RD and Sharma J (2011) Indigenous Knowledge on the Utilization of Medicinal Plant Diversity in the Siwalik Region of Garhwal Himalaya, Uttarakhand. *J For Sci.*, 27(1): 23-31.
- Gaur RD (1999) Flora of the district Garhwal North West Himalaya with ethnobotanical note, Trans media, Srinagar Garhwal.
- Gopalan C, Sastri BVR and Balasubramanian SC (2004) Nutritive value of Indian foods. National Institute of Nutrition, Indian Council of Medical Research, Hyderabad 500007, India. pp: 2-58.
- Hedge JE and Hofreiter BT (1962) In: Carbohydrate Chemistry 17. Whistler, R.L. and J.N. Be Miller, (Eds.), Academic Press, New York.
- Indrayan AK, Sharma S, Durgapal D, Kumar N and Kumar M (2005) Determination of nutritive value and analysis of mineral elements for some medicinally value plants from Uttaranchal. *Curr Sci.*, 89(7): 1252-1255.
- Kalita P, Mukhopadhyay PK and Mukherjee AK (2006) Evaluation of the Nutritional Quality of four Unexplored Aquatic Weeds from Northeast India for the Formulation of Cost-Effective Fish Feeds. *Food Chem.*, 103: 204-209.
- Kayang H (2007) Tribal knowledge on wild edible plants of Meghalaya, Northeast India. *Indian J Tradit Know.*, 6: 177-181.
- Kunwar RM, Burlakoti C, Chowdhari CL and Bussmann RW (2010) Medicinal Plants in Farwest Nepal: Indigenous Uses and Pharmacological Validity. *Med Aromat Plant Sci Biotechnol.*, 4(1): 28-42.
- Lowry OH, Rosebrough NJ, Fan LA and Randall RJ (1951) Protein measurement with the Folin-Phenol reagent. *J Biol Chem.*, 193: 262-275.
- Mahapatra AK, Mishra S, Basak UC and Panda PC (2012) Nutrient Analysis of Some Selected Wild Edible Fruits of Deciduous Forests of India: an Explorative Study Towards Non Conventional Bio-Nutrition. *Adv J Food Sci Technol.*, 4(1): 15-21.
- Maikhuri RK (1991) Nutritional value of some lesser known wild food plants and their role in tribal nutrition. A case study in Northeast India. *Trop Sci.*, 31: 397-405.
- Maikhuri RK and Ramakrishnan PS (1992) Ethnobiology of some tribal societies of Arunachal Pradesh, Northeastern India. *J Econ Taxon Bot.*, 10: 61-78.
- Maikhuri RK, Rao KS and Saxena, KG (2004). Bioprospecting of wild edibles for rural development in the central Himalayan mountain of India. *Mt Res Dev.*, 24: 110-113.
- Maikhuri RK, Semwal RL, Singh A and Nautiyal MC (1994) Wild fruit as a contribution to sustainable rural development: A case study from the Garhwal Himalaya. *Inter. J Sustain Dev World Ecol.*, 1: 56-68.
- Miller GI (1972) Use of dinitrosalicylic acid reagent for determination of reducing sugars. *Anal Chem.*, 31: 426.
- Nwabueze TU (2006) Gelatinization and viscosity behaviour of single screw extrusion in African breadfruit (*Treculia africana*) mixtures. *J Food Process Preserv.*, 30(6): 717-731.
- Ozcana MM and Haciseferogullari H (2007) The strawberry (*Arbutus unedo* L.) fruits: Chemical composition, physical properties and mineral contents. *J Food Eng.*, 78(3): 1022-1028.
- Phondani PC (2011) Worth of Traditional Herbal System of Medicine for Curing Ailments Prevalent Across the Mountain Region of Uttarakhand, India. *J Appl Pharm Sci.*, 01 (09): 81-86.
- Rangana SC (1979) Manual of Analysis of Fruit and Vegetable Products. Tata Mc Graw Hill Publishing Company Limited, New Delhi.
- Rawat S, Jugran A, Giri L, Bhatt ID and Rawal RS (2011) Assessment of antioxidant properties in fruits of *Myrica esculenta*: a popular wild edible species in Indian Himalayan Region. *Evid Based Complement Alternat Med.*, (Article ID 512787), doi:10.1093/ecam/nea055.
- Saha D, Sundriyal M and Sundriyal R (2014) Diversity of food composition and nutritive analysis of wild edible plants in a multi-ethnic tribal land, Northeast India: an important facet for food supply. *Indian J Tradit Know.*, 13(4): 698-705.
- Saklani S, Chandra S, Badoni PP and Dogra S (2012) Antimicrobial activity, nutritional profile and phytochemical screening of wild edible fruit of *Rubus ellipticus*. *Int J Med Arom Plants.*, 2(2): 269-274.
- Samant SS and Dhar U (1997) Diversity, endemism and economic potential of wild edible plants of Indian Himalaya. *Int J Sust Dev World.*, 4: 179-191.
- Sankaran M, Prakash J, Singh NP and Suklabaidya A (2006) Wild Edible Fruits of Tripura. *Nat Prod Radiance.*, 5(4): 302-305.
- Sundriyal M and Sundriyal RC (2001) Wild edible plants of the Sikkim Himalaya: Nutritive values of selected species. *Econ Bot.*, 55(3): 377-390.
- Sundriyal M, Sundriyal RC, Sharma E and Purohit AN (1998) Wild edible and other useful plants from the Sikkim Himalaya, India. *Oecol Mont.*, 7: 43-54.
- Uniyal B and Shiva V (2005) Traditional knowledge on medicinal plants among rural women of the Garhwal Himalaya, Uttaranchal. *Indian J Tradit know.*, 4(3): 259-266.